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UPGRADING READINESS: SUCCESSES AND IMPROVEMENTS OF THE MOBILE PARTS HOPITAL

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ABSTRACT

The Mobile Parts Hospital (MPH) helps the Army with logistical backups in maintaining sustainment and readiness at the battlefield front. Now going into its third phase of the program and scheduled to be transitioned to a Program Manager (PM), the MPH has proven its ability to build parts in a mobile rapid manufacturing environment. This paper will outline the progress of the Lathe Manufacturing Module (LMM) and it's successes in deployment to Kuwait and advances with the Laser Engineered Net-Shaping™ (LENS®) technology and the ability to rapidly build near net shape parts from powdered metal in a mobile environment. The LENS® has been upgraded for increased performance in build speed and advances in near net-shaping of parts. Increased laser power and newly added equipment effects on build profile and deposited material will be discussed, in addition to lessons learned from the current prototype LMM to advances & developments in future changes made to the LMM modules for deployment.

INTRODUCTION

Even those not directly involved with the military realize the Army's mission demands continue to change. The Army has readiness standards to maintain, but an aging weapon system inventory. This has led to a demand by the Army for legacy system parts, and parts from manufacturers that, in some cases, no longer exist. Because the Army is purchasing fewer systems, their requirements are losing priority thereby increasing the lead times for forged and cast items. Additionally, the Army is poised to introduce new systems into the fleet that pose logistical challenges in order to support them at the time of fielding. The combination of these challenges is causing the Army to experience problems in the areas of readiness and sustainment.

The Mobile Parts Hospital is a program that seeks to address some of these challenges. As the project has evolved, the mobile modules are now being referred to as the Rapid Manufacturing System (RMS). The RMS is a mobile manufacturing system that can produce parts rapidly near the point of need. The Command and Control Center (C2) is the link for direct communication between the mobile systems and the Continental United States (CONUS) based Agile Manufacturing Cells (AMC).

The RMS currently consists of two 20' International Standards Organization (ISO) containers, each carrying one piece of manufacturing equipment. The first is a Directed Material Deposition (DMD™) machine that utilizes a patented process called Laser Engineered Net Shaping (LENS™). This machine can create a fully dense metal part from a Computer Aided Design (CAD) model, which is converted to a Standard Triangulation Language (STL) file. After a part is built "near net shape" in this machine, it goes to the other machine - 5-axis multi-task machining center produced by Mazak for final finishing and dimensioning.

When a request for a part comes to the RMS, its on-board databases are searched to determine if that specific part has been built before, or one similar to it. To make the part the RMS must have a complete 3-D model of the requested part. If the data is not available in the databases, on-board equipment is used to create it through CAD/CAM software. Once a 3-D model is obtained, it is converted to a file format that is used by one of the machines in the RMS.

SUCCESSES: LATHE MANUFACTURING MODULE (LMM)

With the proven abilities of the Lathe Manufacturing Module and the Mazak 5-axis mill/turn lathe contained within it, the LMM of the RMS was deployed to Camp Arifjan, Kuwait. This deployment was to prove that the machine could be moved to a forward battle area and manufacture repair parts at the point of need for soldiers. This deployment began in October 2003 and remains there today. This section will describe the successes of this deployment in support of Operation Iraqi Freedom (OIF).

First and foremost the most significant success of the program is the amount of parts produced for OIF. This

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number is over 8800 parts as of December 2004 with an average of 629 parts per month. These parts range from repair parts for vehicles to tools to repair those vehicles and "hard to obtain" tools for soldiers to adjust their M16 rifles.

Most notably the most popular and successful part is a Squad Automatic Weapon (SAW) mount of which the MPH has made over 750. The best part of the story is how the part came to be. A soldier entered the LMM with a problem shortly after the RMS arrived in Kuwait – his SAW mount had design defects that limited his SAW's mobility and ability to spray covering fire for his HMMWV in a wide range. Personnel in the RMS created a rapid solution to the soldier's requests within 2 days, and provided the soldier with a modified adaptor that greatly increased the mobility of the SAW and increased survivability and lethality. Then by word of mouth advertising that the RMS had this part capability the orders multiplied as many HMMWV units wanted this SAW mount for their vehicle. The total number is approaching 750 since October 2003. A photo of this part is shown in Figure 1. This SAW mount won a Top Ten Greatest Army Inventions award in 2003 for the MPH team.

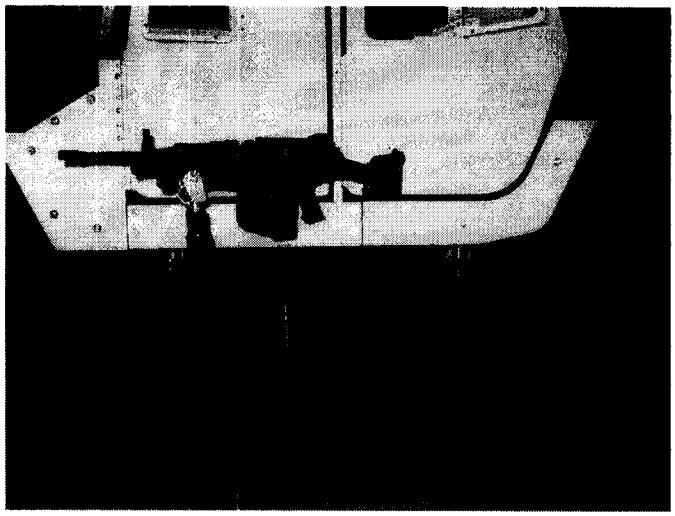

Figure 1. SAW Mount Assembly.

Another part that directly affected the soldier that the MPH has manufactured many of is an M16 sight adjustment tool. This tool is about one inch in length with small 1/8 inch studs on both ends. This parts shows that the MPH can build parts of both small and large magnitude.

Now that the MPH has proven its ability to produce repair parts rapidly (usually days turnaround time) commanders in the field have requested the MPH with requirements documents submitted through TRADOC. This is a large stepping stone to transferring this new technology to the warfighter. More LMM's have been requested and two more are being built for deployment to the Iraq area near the front fighting lines. More about these new modules will be discussed in the Improvements section of this paper.

The deployed Lathe Manufacturing Module (LMM) supports all units deployed to the Southwest Asia (SWA) area. Some of these units include but are not limited to the Forward Repair Area (FRA), 514th Maintenance Company, 1083rd Transportation Company, 368th EN Battalion, and 3rd PERSCOM (Maintenance NCO). Anyone who walks in with low volume and special requests will have his/her needs satisfied.

IMPROVEMENTS: NEW LMM's AND LASER ENGINEERED NET SHAPING (LENS®)

With lessons learned from current LMM deployment to Kuwait the MPH team made redesigns for better efficiency and to eliminate problems that occurred in the hot desert and fine sands of Southwest Asia. These redesigns included changes for easier and quicker setup of the module like electric slide-out expandable room and self leveling hydraulic jacks on the module. The module also includes new amenities for ease of operation such as the new Mazak Integrex 100 SY III to replace the SY II, laptop computers rather than desktops, more 110V outlets and two 220V outlets, larger compressed air tank so multiple tools can be used in conjunction with the Mazak, and easier Mazak machine accessibility for needed maintenance. Additional changes include air compressor ducting for cooling to support operation in temperatures exceeding 140°F and leak proof construction of the module.

The Rapid Manufacturing Module (RMM), however, is still in the R&D phase and has gone through many new improvements. This module contains the LENS® technology and after initial testing the MPH team knew these improvements would have to be made. The major drawback of the LENS® when it was first introduced was its relatively slow build rate. At 0.5 cubic inches per hour build rate the LENS® could not keep up with the turnout rate of the machining center in the LMM. To keep up with the LMM the MPH team had to increase the capability of the LENS® system. The following improvements and changes were made.

To increase build rate of a laser metal deposition machine more energy needs to introduced at the work-piece. With more energy the weldpool can be rastered faster and more material deposited in less time. Knowing this, the MPH team decided to install a larger laser in the LENS® system. The previous 500 Watt Nd:YAG laser was replaced by a 2000 Watt Diode pumped fiber coupled laser. With this larger energy input the build rate increased from 0.5 cubic inches to 3.5 cubic inches per hour or 7X faster. This was the largest improvement of the LENS®.

An improvement that stems directly from having a larger laser and faster build rate is powder supply to the weldpool has to increase as well. With the old powder feeder not enough material was able to get into the weldpool and melted or deposited before the weldpool moved. A new powder delivery system was designed and installed to accommodate the faster deposition rate.

The new powder feeder increased powder capture efficiency from 15% to 35%. A photo of the new powder delivery system is shown in Figure 2.

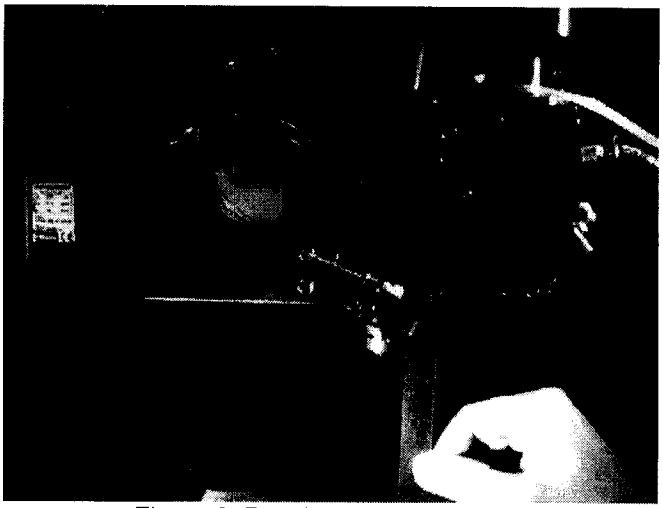

Figure 2. Powder Delivery System.

Control feedback improvements are currently in progress on the machine for weldpool size and distance from powder nozzle to work-piece (Z-height). There are two separate feedback control systems, one for control factor, installed and being tested on the LENS®. The weldpool sensor is a proprietary sensor designed by Optomec. The Z-height controller is a camera that monitors the Z-height optically and adjusts the Z-height continuously as differences from a pre-determined distance occur.

Argon is the inert gas of choice since it truly is inert and does not react in any way with heated material. Problematically, argon is very difficult to get to remote areas where the RMM is planned to operate. To counteract this problem nitrogen is being tested and used as an inert environment for the LENS®. Nitrogen can be generated on-site and, according to recent test results, has no effect on material chemistry with 4140 steel.

FUTURE DIRECTION

Two new LMM's are currently being built. One will be placed at Camp Anaconda in Iraq, closer to the battle area of Operation Iraqi Freedom. The other will be shipped to Afghanistan. One more module is in the plans to be built and used for training at Focus:HOPE in Detroit, MI. When all are finished the Army will own a total of 4 LMM's.

The LENS® will continue to be researched and developed to achieve a 12 cubic inch per hour build rate. Optomec is working this by redesigning a new machine with improvements from lessons learned on the current LENS® machine. When the 12 cubic inches per hour goal is met the RMM will undergo planning for fielding along side a currently deployed LMM. The RMM can reduce the logistics tail of material supply and material waste from the LMM and also has certain repair capabilities being a metal deposition process.

The deployed portion of this program is being transitioned to PM SKOT at Rock Island Arsenal. Rock Island will assume the duties of manning and operating the deployed modules and coordinating with the AMC. The NAC will continue to push the RMM technology with powder metal deposition and all other possible mobile manufacturing technologies.

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ACRONYM LIST

AMC – Agile Manufacturing Cell

C2 – Command and Control Center

CAD – Computer Aided Design

CAM – Computer Aided Manufacturing

CONUS – Continental United States

DMD – Directed Material Deposition

FRA – Forward Repair Area

HMMWV – High Mobility Multi-Wheeled Vehicle

ISO – International Standards Organization

LENS – Laser Engineered Net Shaping

LMM – Lathe Manufacturing Module

MPH – Mobile Parts Hospital

NAC – National Automotive Center

OIF – Operation Iraqi Freedom

PM – Program Manager

RDECOM – Research Development and Engineering Command

RMM – Rapid Manufacturing Module

RMS – Rapid Manufacturing System

SAW – Squad Automatic Weapon

STL – Standard Triangulation Language

TARDEC – Tank Automotive Research, Development & Engineering Center